National Aeronautics and Space Administration

NASA

tech bytes

AMES' EMERGING TECHNOLOGIES

NASA Ames... Making Giant Leaps with Small Missions

Volume 2 • Issue 3 • Summer 2017

In this issue:

Chief Technologist's Corner

It has been a busy summer and fall (which has, among other things, caused us to delay the issuance of this edition of TechBytes). Many of the events that have taken place in that timeframe underscore the diversity and quality of the technology research being conducted at the Ames Research Center.

Over the summer, we invited people to present proposals for the FY18 Center Innovation Fund (CIF), and received over 70 concepts. Soon thereafter, the Center hosted the Internal Research and Development (IRAD) competition, for which we received nearly 100 proposals. We were pleased to see that many proposals for both CIF and IRAD came from first-time proposers. We hope to announce the winners soon.

We also enjoyed working with early career professionals at Ames who wanted to respond to the Space Technology Mission Directorate's (STMD) Early Career Initiative (ECI). Each Center could send forward only three proposals, and I don't envy STMD the challenge of having to downselect to two or three Agency winners. It was tough to get down to just three from Ames.

At the same time, we got to see outcomes of work already funded. This edition features 14 recent or soon-to-be-launched Ames small spacecraft missions, payloads, and related techonologies. These innovative missions will advance exploration, reduce costs, and expand access to space. Also, on September 28, my office joined forces with the Ames Chief Scientist to host "ARTS: Ames Research and Technology Showcase" in Building 3 (see page 7). ARTS starred the recipients of Ames research and technology awards in FY16 and 17. Our objective was for researchers to share their project results with their Ames colleagues. We also hoped to break down organizational stovepipes, and foster collaborations for future calls. In my opinion, the presentations highlighted the range and value of the research being done at Ames. We intend to host a similar event every year, in order to give everyone the opportunity to learn about some of the Center's most innovative and successful technology research. We'd like to thank the Exchange for providing snacks and beverages in support of ARTS.

Other Ames technology events and successes are worth mentioning. My office hosted a second workshop this year, the Machine Learning Workshop, in August. In particular, I would like to note that Ames again won a Software of the Year award, this time for the Terminal Sequencing and Spacing (TSAS) Software for Air Traffic Control. In addition, Ames researcher Jessica Marquez won CNET's 20 Most Influential Latinos in Tech (https://www.cnet.com/news/cnet-en-espanol-the-20-most-influential-latinos-in-tech-2017/). And Ali Guarneros-Luna was featured in BBC Mundo's "One Hundred Women" piece. Stay tuned to learn more about those achievements in our next edition.

- Harry Partridge

ABOUT THE COVER

Fourteen of NASA Ames' small missions, payloads and experiments are highlighted in this edition of TechBytes. They represent only a sampling of the many small missions making a big impact to the NASA mission.

NASA Ames…Making Giant Leaps with Small Missions

NASA Ames has always been positioned on the cutting edge of technology, and small spacecraft missions and payloads, including those based on CubeSats in low Earth orbit and on sounding rockets, are no exception. We highlighted fourteen of Ames' small missions, payloads and experiments that have recently flown, are currently ready for launch, or are in development with launch expected within the next few years. These small missions help NASA advance scientific and human exploration by creating new architectures for a wide range of activities in space, reducing the cost of new space missions, and expanding access to space. Many of the payloads, experiments and components for each of the fourteen were developed at least in part with support from the Center, e.g., Center Innovation Fund or Center Internal Research and Development (IRAD). It can often take years to conceive and mature a technology to the point where it is ready for flight, and a successful effort requires dedication and ingenuity of the Ames' scientist and engineers who design, build and operate these missions. Their contributions to the Ames mission merit a special mention in TechBytes.

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Sub-Orbital Aerodynamic Re-entry EXperiment-8 (SOAREX-8)

Launch Date: *7 July 2015*

SOAREX-8 was a suborbital flight re-entry experiment launched to 280 km altitude from the Wallops Flight Facility. The payload contained several novel technologies that worked together to demonstrate methodologies for space sample return missions and for nanosatellite communications in general. The payload deployed and tested an Exo-Brake, which slows the payload aerodynamically, providing eventual de-orbit and recovery of future ISS samples through a Small Payload Quick Return project. In addition, the flight addressed future Mars entry technology, space-to-space communications using the Iridium Short Messaging Service, GPS tracking, and wireless sensors using the ZigBee protocol. SOAREX-8 was assembled and tested at Ames, and the sensor and communications work was funded by the NESC. PI/PM: Marcus Murbach (NASA Ames).

Edison Demo of Smallsat Networks (EDSN)

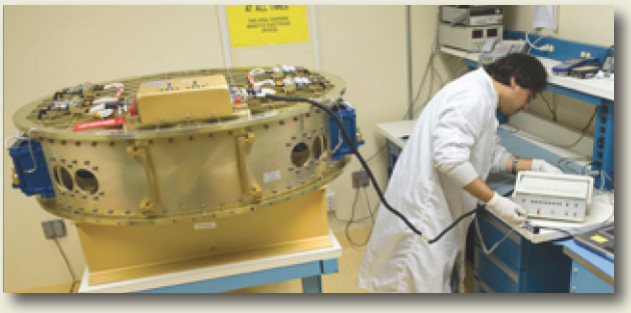
Launch Date: *3 November 2015 (launch failure)*

The EDSN mission was lost in a launch vehicle failure during the USAF-led Operationally Responsive Space Office's ORS-4 mission that was carrying them to orbit as a secondary payload. The goal of EDSN was to demo an interactive satellite swarm of eight 1.5 U CubeSats capable of collecting, exchanging and transmitting multi-point scientific measurements. The EDSN satellites employed commercial smartphone processors to perform many of the spacecraft functions normally accomplished with expensive, customized electronics components. The satellites were to use time and orbital knowledge provided by GPS to autonomously plan activities including recording sensor data of the intensity of energetic charged particles, exchanging inter-satellite data and downlinking data to a ground station. EDSN was a partnership between NASA Ames, MSFC, Montana State University, and Santa Clara University. EDSN was funded by NASA's SSTP. PM: Deborah Westley (NASA Ames).

Nanosat Launch Adapter System (NLAS)

Launch Date: *3 November 2015 (launch failure)*

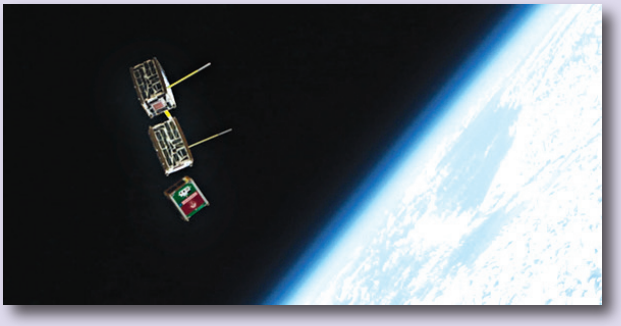
The NLAS was developed to increase access to space while simplifying the integration process of nano- or CubeSats onto a variety of launch vehicles. A single NLAS provides the capability to deploy 24U of CubeSats. The system enables flight demos of new technologies in the space environment, and consists of an Adapter, four Dispensers and a Sequencer. The Adapter is mounted to the launch vehicle or the primary mission spacecraft. The Dispensers are mounted inside the Adapter and house a variety CubeSats configurations in fully enclosed bays. Each Dispenser can accommodate a total payload weight of up to 30 pounds (14 kg). To increase the number of secondary payloads, multiple NLAS can be stacked on the launch vehicle. The Sequencer is a self-powered reprogrammable unit that signals the separation of each dispenser bay, or other deployment mechanisms. PM: Mina Cappuccio (NASA Ames).



Network & Operation Demo Satellite (NODeS)

Launch Date: *6 December 2015*

Nodes is a technology demo mission that consisted of two 1.5U nanosatellites that were deployed from ISS on 16 May, 2016 to demonstrate new network capabilities critical to the operation of swarms of multiple spacecraft. Nodes continued the legacy of the PhoneSat series that first introduced and successfully implemented the use of Android Smartphone technology to perform many of the functions previously accomplished through custom technology development efforts. Each Node performed command and data handling tasks that allow the satellites to: 1) relay ground commands through one satellite to the second satellite; 2) collect and relay multipoint science data on the radiation environment in the ISS orbit from each satellite to the ground station; and 3) autonomously determine which of the two satellites is best suited to control the space network. Nodes is funded by SSTP and by the Engineering Directorate at NASA Ames. PM: John Hanson (NASA Ames).



Sub-Orbital Aerodynamic Re-entry EXperiment-9 (SOAREX-9)

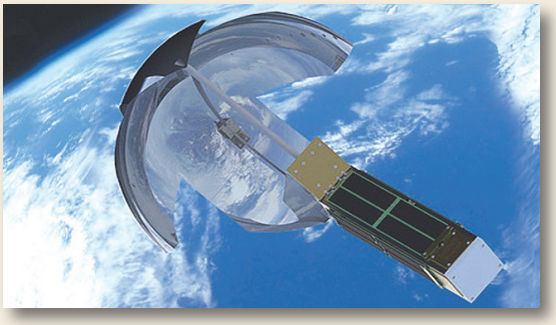
Launch Date: *7 March 2016*

SOAREX-9 was a suborbital flight re-entry experiment launched aboard a Terrier-Orion sounding rocket featuring a recoverable payload section, so that much of the flight hardware could be reused for subsequent flights after post-flight evaluation. The major mission objectives are to test a Wireless Sensor Modules (WSM), its host avionics system based on the Intel Edison (PhoneSat5) platform and a high-speed downlink based on the IEEE 802.11b WiFi. Experimental results are applied to the TechEdSat-6 and TechEdSat-7 missions launched from the ISS in 2017. SOAREX-9 also enabled development of techniques needed to retrieve optical and WSM data through the downlink directly to the satellite telemetry receivers at Wallops during a TechEdSat-5 over flight. PI/PM: Marcus Murbach (NASA Ames).

Technology Educational Satellite-5 (TechEdSat-5 or TES-5)

Launch Date: *9 December 2016*

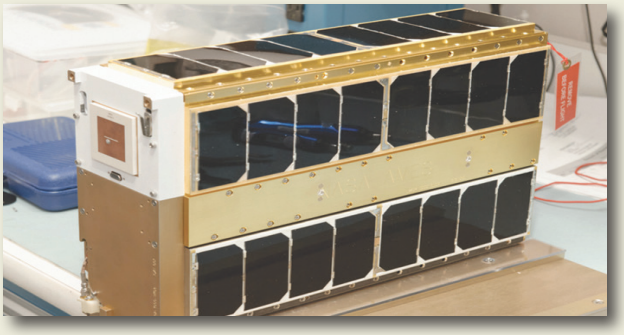
TES-5 was as a collaborative engineering project between NASA Ames, San Jose State University and the University of Idaho. The TES-5 satellite is based on the TechEdSat-4 design, but used an enlarged 3.5U CubeSat bus. It introduced a modulating exo-brake capable of changing its surface area allowing the satellite to more precisely enter the atmosphere. The goals of TES-5 were to establish improved uncertainty analysis for eventual controlled flight through the Thermosphere; improve prediction of re-entry location; provide the base technology for sample return technology from orbital platforms and the eventual testing of independent TDRV-based planetary missions, and provide engineering data for an On-Orbit Tracking Device that could improve the prediction of jettisoned material from the ISS. PI/PM: Marcus Murbach (NASA Ames).



E. coli AntiMicrobial Satellite (EcAMSat)

Launch Date: *11 November 2017*

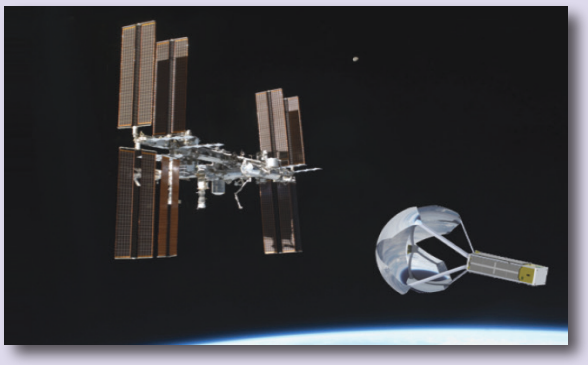
The EcAMSat mission will investigate how and whether space microgravity affects the antibiotic resistance of ***E. coli***, a bacterial pathogen responsible for urinary tract infection in humans and animals. Bacterial antibiotic resistance may pose a danger to astronauts in microgravity, where the immune response is weakened. Scientists believe that the results of this experiment could help design effective countermeasures to protect astronauts' health during long-duration human space missions. EcAMSat is a partnership between NASA Ames and Stanford University School of Medicine. EcAMSat is the first 6U experiment in a 2x3 U configuration deployed from the ISS. It will spend a minimum of 45 days in low-Earth orbit completing the experiment and relaying data to the ground. EcAMSat is funded by the Space Life and Physical Sciences Research Division within HEOMD. PM: Stevan Spremo (NASA Ames).



Technology Educational Satellite-6 (TechEdSat-6 or TES-6)

Launch Date: *12 November 2017*

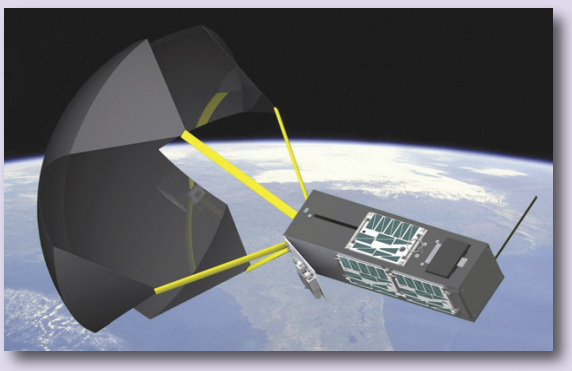
TES-6 is a 3U CubesSat that is the 6th generation in the continuing TechEdSat series. TES-6 is developing experimental techniques for the Exo-Brake system, including advanced targeting and fully propellant-less de-orbiting. TES-6 has a dual T6P6 avionics bus and the first wireless communications/control within the nano-sat. It has a total of 6 micro-processors, and further develops the next generation Wireless Sensor Module (WSM). TES-6 is developed in partnership with San Jose State University and the University of Idaho as a collaborative engineering project, with oversight by NASA Ames and funding from NASA's Space Technology Mission Directorate's Game Changing Development Program. It was selected in 2017 by NASA to be launched as part of the Educational Launch of Nanosatellites (ELaNa) Program. PI/PM: Marcus Murbach (NASA Ames).



Technology Educational Satellite-7 (TechEdSat-7 or TES-7)

Launch Date: *2018*

TES-7 is a 2U CubeSat built as a conjoined project between San Jose Satate University and the University of Idaho as a collaborative engineering project, with design oversight and I&T from NASA Ames, and funding from NASA's Space Technology Mission Directorate's Game Changing Development Program. It is a technology demonstration mission that further develops the Exo-Brake system by testing a high Packing Density Exo-Brake, with increasingly rapid de-orbit and re-entry from higher orbits (targeting or disposal). It was selected in 2017 by NASA to be launched as part of the Educational Launch of Nanosatellites (ELaNa) Program, next year. PI/PM: Marcus Murbach (NASA Ames).



BioSentinel

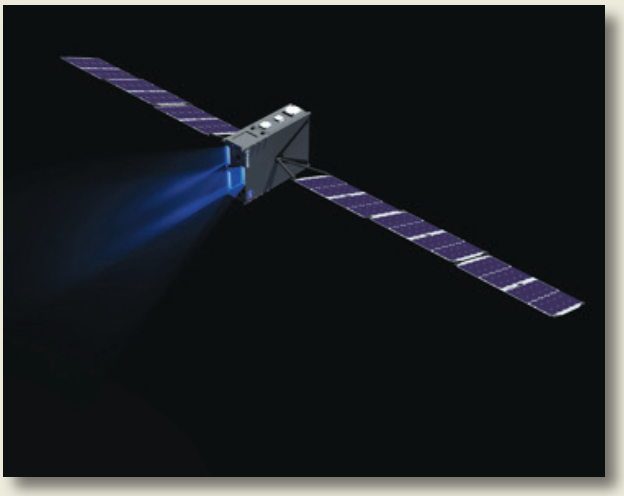
Launch Date: *July 2018 (planned)*

The BioSentinel mission was selected as one of the secondary payloads to fly on the first SLS Exploration Mission (EM-1). The primary objective of BioSentinel is to develop a biosensor using a simple model organism to detect, measure, and correlate the impact of space radiation to living organisms over long durations beyond LEO. BioSentinel is a 6U CubeSat that will carry multiple cultures of genetically modified and control strains of yeast cells that researchers will use to quantify the damaging effects of radiation by measuring relevant growth and metabolic changes. Also on board are a radiation spectrometer and a dosimeter for taking radiation measurements. BioSentinel is funded by the Advanced Exploration Systems program within the HEOMD, and is a partnership between NASA Ames, JSC, Loma Linda University Medical Center, and the University of Saskatchewan, Canada. Lead Scientist: Sharmila Bhattacharya (NASA Ames).

Pathfinder Technology Demo-1 (PTD-1)

Launch Date: *2018 (planned)*

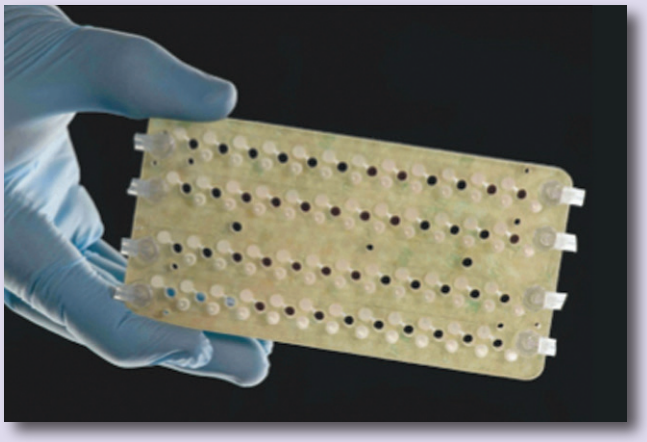
PTD-1 is a 6U CubeSat technology demonstration mission that will test the operation of a variety of CubeSat subsystems in low-Earth orbit, providing significant enhancements in performance. The PTD project, led by Ames in collaboration with GRC, will benefit future missions by demonstrating the operation of new subsystem technologies on orbit, including propulsion systems and a novel technology to stabilize spacecraft and laser communications systems. The PTD mission is funded through NASA's Small Spacecraft Technology Program (SSTP). PM: Elwood Agasid (NASA Ames).



PowerCell Spaceflight Payload

Launch Date: *2018 (planned)*

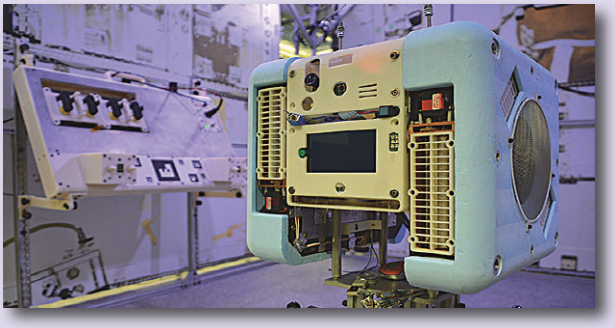
PowerCell is a biological science secondary payload that will launch on DLR's Eu:CROPIS (Euglena & Combined Regenerative Organic-food Production In Space) mission. Powercell is based on an idea developed by a team of college students for the IGEM international synthetic biology competition. PowerCell uses synthetically altered organisms to produce food/nutritional supplements for long duration missions, and seeks to develop a sustainable energy source to power biological manufacturing using inputs that would be found in situ on the moon or Mars. This concept will be tested under microgravity, lunar, and martian gravity regimes, that are artificially produced but the rotation of the Eu:CROPIS spacecraft. PI: Lynn Rothschild (NASA Ames).



Astrobee

Launch Date: *2018 (planned)*

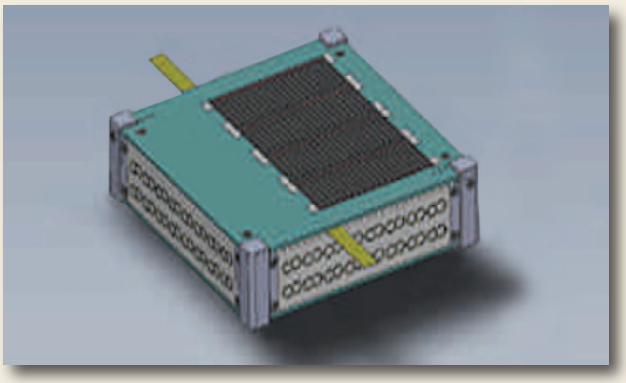
Astrobee is a robot that will soon be flying around the International Space Station (ISS) alongside the astronauts. This compact, 1 foot by 1 foot by 1 foot cube is designed to help scientists and engineers develop and test technologies for use in zero-g, help the astronauts do their routine chores, and give flight controllers in Houston additional eyes and ears on spacecraft. Designed by the Ames Intelligent Robotics Group, Astrobee will replace an aging SPHERES (Synchronized Position Hold Engage and Reorient Experimental Satellite), NASA's first generation free-flyer now aboard the ISS. Astrobee can take on research, housekeeping, and monitoring duties without astronaut supervision—Astrobee can operate either in fully automated mode or under remote control from Houston, without wasting valuable astronaut time. Astrobee is funded by the NASA Game Changing Development Program and is planned to launch to the ISS in 2018. PI: Terry Fong (NASA Ames).



Global Network of Swarms (GNS)

Launch Date: *2018 (planned)*

The GNS is a technology demonstration mission of swarm networking algorithms using eight small, chip-based spacecraft called Basic Electronic Elements, or BEEs, provided by Swarm Technologies, LLC. These flat, single board spacecraft are fully autonomous and capable of forming radio frequency networked nodes in space. The 8 BEE spacecraft, aggregated into their 1U cubesat carrier/deployer is termed the GNS spacecraft. Swarms or constellations of BEEs can relay data in real-time and can create global space-based relay networks for scientific, industrial, and government applications. GNS was selected in 2016 by NASA to be launched as part of the Educational Launch of Nanosatellites (ELaNa) program.



Seeking the Tricorder: Workshop on Advanced Technologies for Life Detection

The Tricorder workshop was conducted at Ames May 19-20, 2017. The workshop was sponsored by the Ames Office of the Chief Technologist (CCT) in collaboration with the NASA Astrobiology Institute (NAI). Impetus for the workshop came from NASA HQ Space Technology Mission Directorate (STMD) management, specifically Drs. Denise Podolski and Jay Falker.

The goal of the workshop was to develop innovative concepts for low TRL advanced life detection technologies that could be applied to the surface and near-subsurface of Mars and Ocean Worlds (such as Europa and Enceladus) dominated by icy terrain. The technology focus was on mid-to-far term instrument concepts or other enabling technologies primarily for landed missions, which could detect evidence of extant, extinct, and/or "weird" life including the notion of a "universal biosignature." Emphasis was placed on simultaneous and serial sample measurements utilizing a suite of instruments and technological approaches. Participants explored technology topics including portable, miniature sensor platforms, spectrometry, imagery, remote sensing focused on non-invasive methods for life detection. Tensegrity robotics explorers that can access subsurface and other challenging surface terrain of Icy Worlds were discussed along with other robotic approaches to challenging terrains. Advances with small satellites including sensor swarm networks and telemetry and advanced algorithms for predicting life and life patterns by connecting sensor swarms and robotic explorers were considered. Planetary protection principles surrounding such exploration informed the entire event.

Since Non-NASA participants who weren't necessarily familiar with the challenges and limitations of space systems were invited to attend the workshop, the range of environmental conditions that a mission may encounter on the candidate destinations was discussed and characterized. Planetary protection requirements and current approaches to meet the goals of international planetary protection agreements were covered. Much of this information was provided to all participants in the form of "fact sheets" prior to the conference via the conference registration site. Additional workshop pre-work information and website links were also provided. Several invited talks were presented the first day of the workshop to provide context and background on topics such as planetary protection, small satellites, algorithms, robotics and innovative engineering concepts like origami-inspired materials. On day two, presentations were given from STMD program managers and from NIAC.

Dr. Harry Partridge delivering opening comments at the Life Detection workshop. Image credit: Dominic Hart

We connected 75 invited participants from traditional NASA technology, science and engineering communities with participants from non-NASA agencies and organizations with relevant technologies not previously applied to space mission applications. Participant expertise included robotics, mining, machine learning, materials, thermodynamics, medical, origami, and military technologies.

Concepts were developed and facilitated in four breakout sessions to develop approaches to extant life detection at 3 mission destinations:

- *Mars- Recurring Slope Linnae (RSL) and Subsurface access (caves) and rock overhangs*
- *Icy Moons-Enceladus and Europa's fractures and plumes and also by direct access via drill, plow or melting devices*

Life detection instrumentation concepts from the workshop outlined in the final report will provide STMD with technology areas necessary to solicit and develop for future life detection exploration missions via fly-by or landers. ■

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ARTS: Ames Research and Technology Showcase

On September 28, the Ames community was invited to ARTS: Ames Research and Technology Showcase. This event was held in the Conference Center and was co-sponsored by Center Chief Technologist and Office of Chief Scientist. The showcase highlighted the recipients of FY 16/17 Center Innovation and Science Innovation Funds (CIF/SIF), Director's Discretionary Funds (DDF) and Internal Research and Development (IRAD) awards. The technologists and researchers presented posters and a subset gave 3 minute lightning talks to over 150 Ames colleagues while enjoying happy hour, munchies and networking. The HQ STMD CIF Program manager, Ricky Howard, participated at the event. Positive feedback and likely new research collaborations will lead to innovative proposals for the next round of these Center solicitations. The hosting offices are grateful to the Exchange for providing the munchies. ■

ARTS event at Ames held on September 28, 2017. Image Credit: NASA Ames

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Upcoming Activities & Events

NASA Solicitations

Space Technology Mission Directorate – PROPOSALS DUE: **Nov. 17, 2017** (5:00 p.m. Eastern Time)
NASA Flight Opportunities (FO): Technology Advancement Utilizing Suborbital Flight Opportunities
https://nspires.nasaprs.com/external/solicitations/summary!init.do?solId=%7B6F46BA07-884E-59F9-9E8A-BAE0B5B4B616%7D17FO F1(B)

Human Exploration and Operations Mission Directorate – RESPONSE DATE: **Nov. 21, 2017**
Announcement of CubeSat Launch Initiative
https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=42daa154fcb26b83a06a86cee8446ef4

External Solicitations

Defense Advanced Research Projects Agency (DARPA) – RESPONSE DATE: **April 26, 2018**
Biological Technologies Office, Biological Technologies, Solicitation Number: HR001117S0030,

Proposed research should investigate leading edge approaches that enable revolutionary advances in science, technologies, or systems at the intersection of biology with engineering and the physical and computer sciences. Specifically excluded is research that primarily results in evolutionary improvements to the existing state of the art. BTO seeks unconventional approaches that are outside the mainstream, challenge assumptions, and have the potential to radically change established practice, lead to extraordinary outcomes, and create entirely new fields.

APPEL Courses held at Ames

COURSE: **APPEL-Team Leadership –** DATE: **Jan. 22-24, 2018** *(Registration opens Oct. 30, 2017, Registration Deadline: Jan. 8, 2018)*
COURSE: **APPEL- Introduction to PM at NASA** – DATE: **Feb. 26-28, 2018** *(Registration opens Oct. 30, 2017, Registration Deadline: Feb. 12, 2018)*

Events & Conferences

■ NOVEMBER 16-18
Space Vision 2017
Cape Canaveral, Florida,
https://spacevision.seds.org

■ NOVEMBER 26 – DECEMBER 1
Materials Research Society – 2017 Fall Meeting and Exhibit
Boston, Massachusetts
http://www.mrs.org/fall2017

■ DECEMBER 5-7
Space Commerce Conference & Exposition (SpaceCom) 2017
Houston, Texas, *http://spacecomexpo.com*

■ DECEMBER 18-20
Next Generation Suborbital Researchers Conference (NSRC-2017)
Broomfield, Colorado,
http://www.boulder.swri.edu/NSRC2017/Site4/Home.html

■ JANUARY 8-12, 2018
AIAA SciTech Forum
Kissimmee, Florida
https://scitech.aiaa.org